CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS
MINES BRANCH

OTTAWA

FUELS AND MINING PRACTICE DIVISION

INTERNAL REPORT FMP 62/34-RBS

PROPOSALS AND DISCUSSIONS REGARDING STANDARD SPECIFICATIONS FOR CLASSIFICATION OF COAL BY RANK (ASTM D 388-38)

by

Lewis H. King

Prepared for circulation to members of ASTM
Committee D 5, Subcommittee XVIII.

March, 1962

PROPOSALS AND DISCUSSIONS REGARDING STANDARD SPECIFICATIONS FOR CLASSIFICATION OF COAL BY RANK (ASTM D 388-38)

by

Lewis H. King*

Three meetings have now been held since the reactivation of ASTM D-5 Subcommittee XVIII on classification of coals. As a result of these meetings, the major problems regarding D 388-38 appear to have been resolved into at least five categories: (a) classification of lignitic coals, (b) differentiation of subbituminous A and high volatile C bituminous coals, (c) considerations related to the use of the term "rank" in conjunction with commercial coal preparation, (d) discussion of errors in ash determination resulting from the retention of significant amounts of SO_3 in the ash of low rank coals, and (e) consideration of classification systems other than D 388-38. The writer has subsequently discussed these problems with the following members of the Fuels and Mining Practice Division: Dr. D.S. Montgomery, and Messrs. A. Ignatieff, E. Burrough, T. Tibbetts, and W.J. Montgomery. This report reviews the current issues before Subcommittee XVIII pertaining to D 388-38; it presents our tentative proposals for items (a) and (b) and discusses items (c), (d), and (e).

---

* Senior Scientific Officer, Fuels and Mining Practice Division, Mines Branch, Department of Mines and Technical Surveys, Ottawa, Ontario.

Classification of Lignitic Coals

There seems to be general agreement that the terms "Brown Coal", "Consolidated" and "Unconsolidated" should be dropped for reasons discussed at the previous meetings. It appears desirable, however, to subdivide lignite on another basis such as moisture content or moist Btu (mineral-matter-free basis) rather than leave it as one group. With a few exceptions, the majority of American and Canadian coals of the lignitic class fall in the lignite group, but many lignitic coals from other parts of the world, e.g. Germany and Australia, fall in the brown coal group of D 388-38 and it is felt that the ASTM classification would have greater universal appeal if this latter group could receive distinct recognition.

Figure 1 of this report shows that the lignite and brown coal groups can be distinguished by a 50% moisture (ash-free basis) division even though the ASTM designations were made on the rather subjective basis of degree of compaction. This shows that the degree of compaction has a natural significance but it would be more quantitative and much easier to use ash-free moisture or moist Btu (mmf) as the parameter.

As a suggestion, table 1 of D 388-38 could be set up as follows for the lignitic coals.

TABLE 1

Classification of Lignitic Coals using Ash-free Moisture

Class	Group	Limits of Fixed Carbon or Btu Mineral-Matter-Free Basis
IV. Lignitic	1. Lignite A coal	Moist Btu, less than 8300 Moisture content (ash-free) less than 50%
	2. Lignite B coal	Moist Btu, less than 8300 Moisture content (ash-free) greater than 50%

The alternate proposal of using moist Btu (mmf) is more highly favored by the Ottawa group as thermal energy is already the criteron for differentiating most of the low rank coals in the present ASTM system. On the basis of figure 1 the writer has chosen a moist Btu of 6,300 (mmf) as the division which would most readily fit the pattern set by the old method of establishing the divisions, namely the consolidated and unconsolidated criteria.

On the basis of a division at 6,300 moist Btu, Table 1 of D 388-38 could take the following form:

TABLE 2

Classification of Lignitic Coals using Moist Btu (mmf)

Class	Group	Limits of Fixed Carbon or Btu Mineral-Matter-Free Basis
IV. Lignitic	1. Lignite A coal	Moist Btu 6,300 or more and less than 8,300
	2. Lignite B coal	Moist Btu less than 6,300

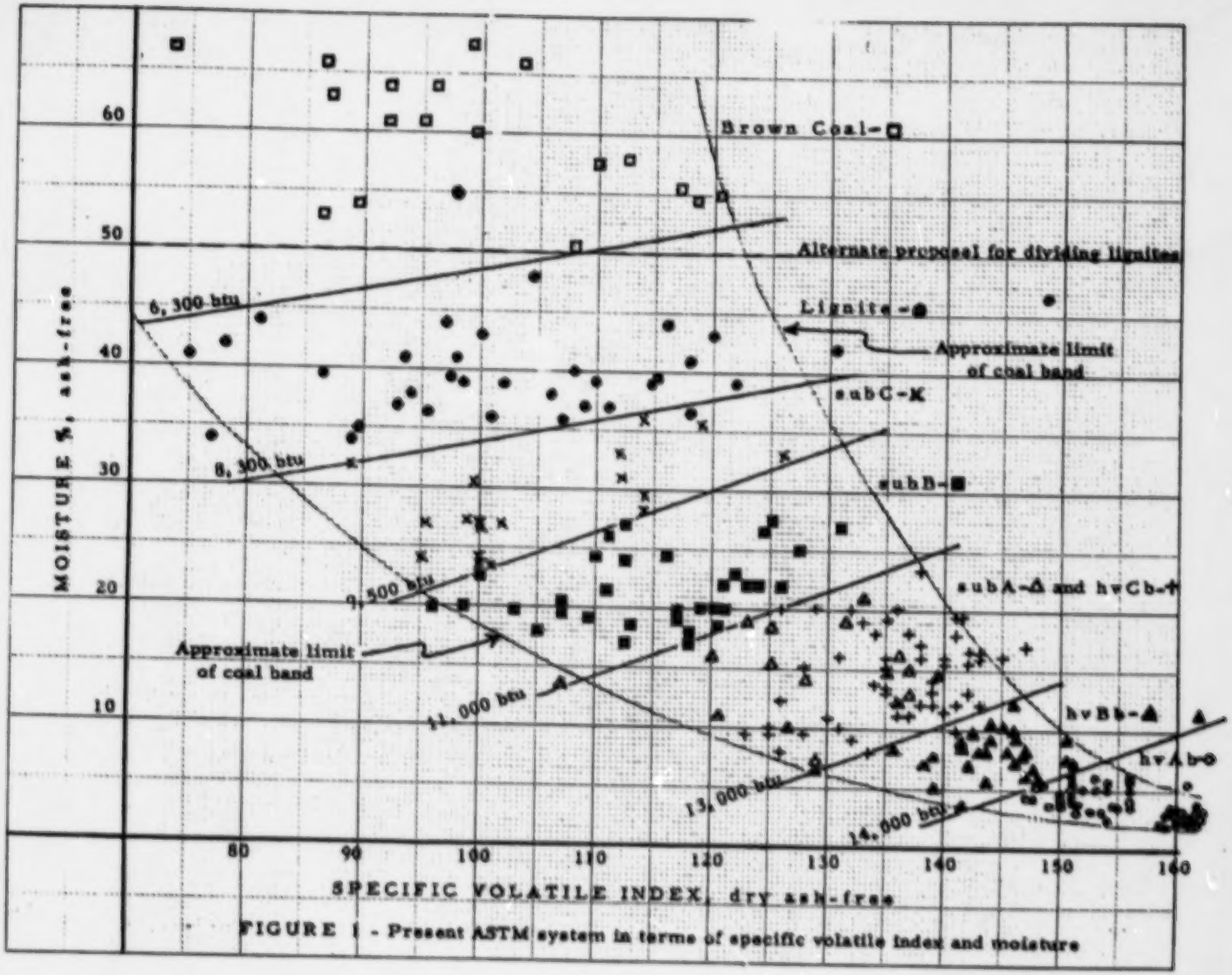

FIGURE 1 - Present ASTM system in terms of specific volatile index and moisture

Classification of Subbituminous A and High Volatile C Bituminous Coal

D 388-38 was originally designed to utilize both weathering and agglomerating index as requisite physical properties in making the distinction between subbituminous A and high volatile C bituminous coals. In practice, weathering has not been used extensively and at the present time does not appear to be used in any laboratory. Furthermore, no strong arguments for its retention have been put forth at the committee meetings thus far. Therefore, it is the opinion of this group that the weathering index should be dropped, at least as a parameter for establishing rank.

The agglomeration index has been more widely used as a parameter; however, it fails to establish a clear break between subbituminous A and high volatile C bituminous coals in a manner compatible with the basic parameter, i.e. moist Btu. This becomes evident in figure 1 where approximately 275 coals are plotted in terms of "Specific Volatile Index" and ash-free moisture, and the ASTM group divisions are established on an emperical basis from the distribution of the points. Both the subbituminous A and high volatile C bituminous groups form well defined boundaries with the adjacent groups: subbituminous B and high volatile B bituminous, but a great deal of mixing or "overlap" occurs between these boundaries. The extent of the gap between the high rank boundary of subbituminous B and low rank boundary of high volatile B bituminous as compared to the distance between other group boundaries seems to indicate that

a boundary between subbituminous A and high volatile C bituminous is justified. On the basis of this comparison it is thought that a parameter other than agglomerating index should be used to define this boundary. Furthermore, it has been recognized for many years, on the basis of moist Btu values alone, that "overlap" occurs between subbituminous A and high volatile C bituminous coals. The reason that the agglomeration test does not establish a clear cut division in terms of other basic parameters of coal is not known, as the property is not clearly understood from the scientific viewpoint. It is known, however, that the property is quite highly dependent on heating rate, oxidation, and petrographic composition. These factors might in part be responsible for the "overlap" when agglomeration is employed.

In the event that the weathering and agglomeration tests are dropped, another parameter must be introduced if the groups subbituminous A and high volatile C bituminous are to be retained. The most logical and consistent choice appears to be the moist mineral-matter-free Btu which is used for distinguishing the other low rank groups. It is suggested that this matter be given further consideration by the committee and task group. There seems to be considerable merit to the idea of establishing all the low rank divisions on a quantitative energy basis, not only for the purpose of establish-

ing uniformity and a higher degree of symmetry throughout the low rank system, but also considering the fact that coal is bought and sold on an energy basis, and this particularly applies to high moisture coals that presently have few other outlets. As will be pointed out later, it would also simplify the possibilities for further modification and refinement to the present system.

On the assumption that further consideration will be given to the establishment of all the low rank group divisions on a moist Btu (mmf) basis, the following thoughts are presented to initiate discussion on the matter. The moist Btu interval now used to define both the high volatile C bituminous and subbituminous A groups is 2,000, i.e. between 11,000 and 13,000 Btu, and this interval is higher than any other dividing the low rank groups. As a first approximation, the creation of two 1,000 Btu intervals, one for each of the groups in question, might serve as a suitable starting point, i.e. a division between high volatile C and subbituminous A at 12,000 Btu. This was suggested at the Pittsburgh meeting.

After having made a rather comprehensive survey of Canadian coals and to a lesser extent the Illinois coals, it has been found that a large number of high volatile C bituminous coals presently classified on the basis of their agglomerating and weathering characteristics would fall in the subbituminous A group if the division were to be made at 12,000 Btu. Any change in the method of classifying these coals will undoubtedly shift some in their classifi-

cation, but it is thought that the majority of boundary coals should be upgraded rather than downgraded in rank. In other words, the division should be chosen in such a manner that the majority of coals will not be adversely classified, but the choice should not depart an unreasonable distance from what appears to be the natural position for the division from the point of view of maintaining symmetry within the system. With these thoughts in mind the Ottawa group feels that a division at 11,500 Btu would possibly be the best choice. Under these conditions the majority of Canadian coals would remain unchanged while a few of the Illinois coals, mostly from the northern part of the state, would be downgraded to subbituminous A. It is not known if these downgraded Illinois coals would involve operating mines.

If the division between high volatile C bituminous and subbituminous A were to be established at 11,500 Btu, then the interval for subbituminous A would only be 500 Btu which seems rather small. This difficulty could be overcome by lowering the upper boundary of subbituminous B from 11,000 to 10,500 Btu. The interval for subbituminous A would then be increased to 1,000 and the present subbituminous B interval would be reduced from 1,500 to 1,000.

These suggested changes are summarized in Table 3 and it can be seen that the overall symmetry of the system is enhanced.

TABLE 3

Comparison of the Present and Proposed ASTM Systems for Classifying High Volatile and Subbituminous Coals

Class	Group	Limits of Moist Btu (mmf)		Btu Interval	
		Present	Proposed	Present	Proposed
II. Bituminous	3. hvAb	14,000 or more	14,000 or more	-	-
	4. hvBb	13,000 or more and less than 14,000	13,000 or more and less than 14,000	1,000	1,000
	5. hvCb	11,000 or more and less than 13,000	11,500 or more and less than 13,000	2,000	1,500
III. Subbituminous	1. subA	11,000 or more and less than 13,000	10,500 or more and less than 11,500	2,000	1,000
	2. subB	9,500 or more and less than 11,000	9,500 or more and less than 10,500	1,500	1,000
	3. subC	8,300 or more and less than 9,500	8,300 or more and less than 9,500	1,200	1,200

Figure 2 is another plot of the same coals used in figure 1 but is different in that each point was designated according to the proposed ASTM system as set forth in tables 2 and 3. On this plot the group division lines can be empirically established with very little "overlap" between groups, whereas figure 1 shows complete overlap in the subbituminous A - high volatile C area of the diagram. This illustrates the merit of basing the ASTM system entirely on a moist Btu basis. It should be pointed out that the position of the ASTM division lines on figures 1 and 2 is not established with a high degree of ac-

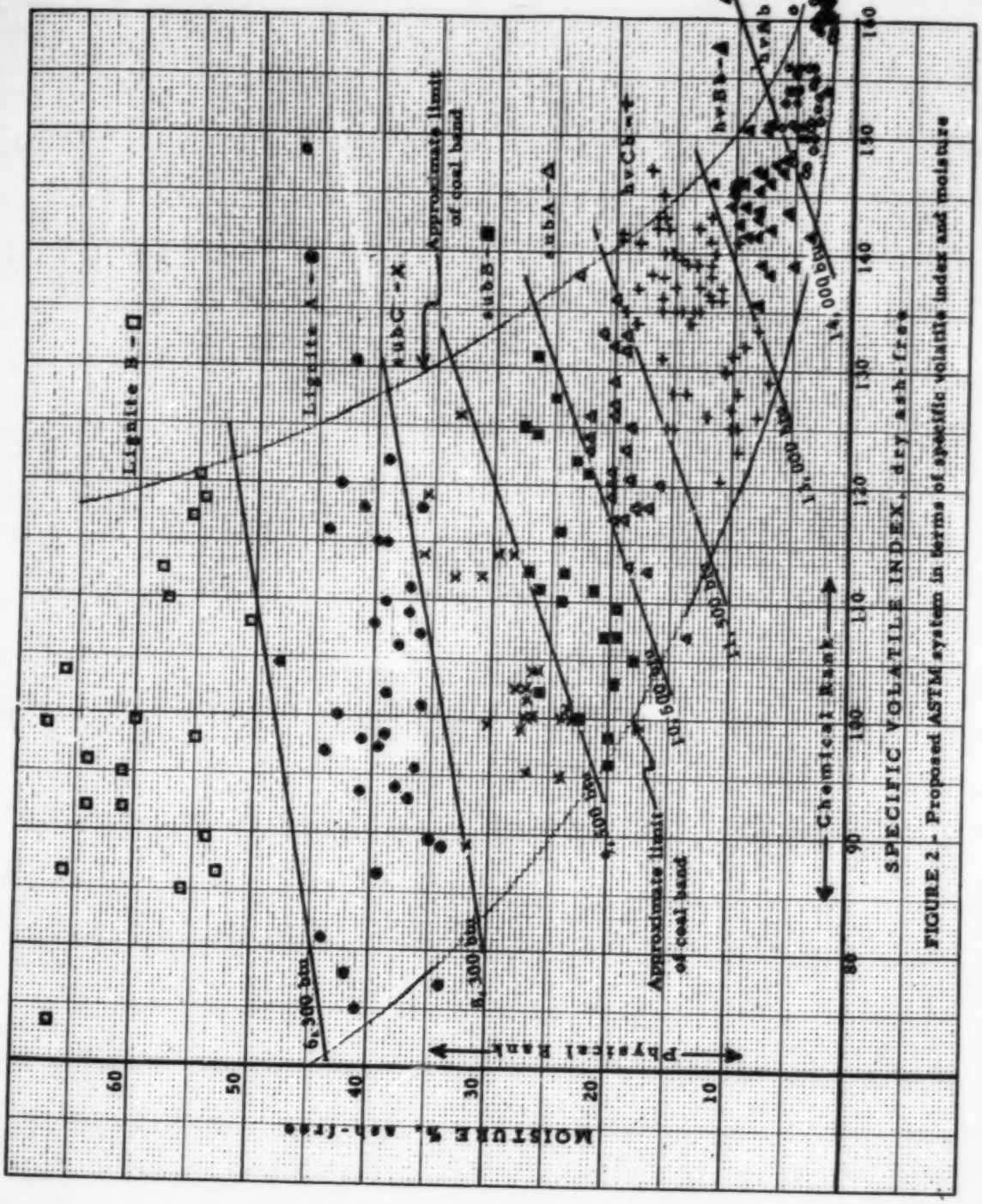

FIGURE 2 - Proposed ASTM system in terms of specific volatile index and moisture

curacy and many more points would be required to obtain high accuracy. The division lines are sufficiently accurate, however, to illustrate the arguments for an ASTM system for low rank coals based entirely on a moist Btu (mmf) basis.

In summary, the Ottawa group is proposing that the ASTM classification system for low rank coals be based entirely on the quantitative parameter: moist Btu (mmf). The location of the divisions as specified in tables 2 and 3 are proposals representing our tentative thoughts. An attempt has been made in figures 1 and 2 to illustrate the arguments in terms of specific volatile index and ash-free moisture, but it is not intended that specific volatile index and moisture be used as parameters in defining the ASTM groups. It will, however, be shown in the last section of this report that the specific volatile index could be used to quantitatively qualify the coals that fall within any given ASTM group.

Use of the term "rank" in conjunction with commercial coal preparation

The discussion promoted by Dr. J.M. Schopf regarding the use of face-channel samples only for rank determination appears to be justified. He maintains that the classification of tipple or shipment samples should be in terms of "equivalent" rank, since rank assigned to these samples may not correspond to the average metamorphism of the bed, and hence do not agree with the scope implied for this classification. Petrographic segrega-

tion and oxidation are apparently the most serious factors as the moisture problem can now be handled satisfactorily through equilibration, unless the samples are of extreme low rank and have lost moisture to the point where they cannot be equilibrated back.

The Ottawa group is in agreement with Dr. Schopf's proposal, but there has been some discussion at the committee to the effect that the term "equivalent" might be slightly ambiguous so for this reason it should receive further discussion.

Retention of Abnormal Amounts of Sulphur in Low Rank coal ash

The question raised by W.H. Ode regarding errors in ash determinations resulting from the retention of significant amounts of SO_3 in the ash of low rank coals is important, but discussion should be withheld until publication of Ode's pending report.

Consideration of Classification Systems other than D 388-38

A number of possibilities for additional classifications have been brought before the present committee and task group, however, in this report the writer only intends discussing the specific volatile index and the manner in which it might be used to qualify and enhance the proposed ASTM system set forth under the first two headings of this report and summarized in tables 2 and 3. In the Fuels Division Memorandum IR-FMP-61/26-RBS it was shown that the concepts of "physical" and "chemical" rank are important factors to recognize in understanding the

classification of low rank coals. A quantitative measure of chemical rank can best be realized through per cent ultimate carbon or specific volatile index. Of these parameters, specific volatile index has the advantage since it can be readily calculated from proximate analysis data. Physical rank refers to the total pore volume of the coal which is a function of the degree of physical compaction after burial; thus, the degree of physical rank can be expressed by the equilibrated moisture content. In other words, the advancement of physical rank is expressed by dehydration resulting from the application of pressure. The concomitant chemical changes that take place during this stage of coalification are slow.

Figure 2 shows that the ASTM group boundaries more closely conform to the moisture divisions than the specific volatile index divisions showing that the ASTM classification is highly physical in character. This results from the fact that the Btu values of the coals are highly diluted by their moisture contents. This is not intended as a criticism of the ASTM system but is mentioned in order to indicate the strong physical aspect of the system. On the other hand, some classifications are dominated by the chemical rank aspect, for example Seyler's classification. None of the existing classifications seem to place the low rank coals in proper perspective with respect to the physical and chemical rank concepts, but rather emphasize one or the other. It is suggested that it might be worthwhile to attempt such a scheme

using the ASTM system as a basis. This could be achieved using the specific volatile index and would not require data beyond that normally obtained from a proximate analysis; however, it would first be necessary to adopt the proposal of establishing all the low rank divisions on a moist Btu basis.

Figure 2 shows a considerable spread of points within each ASTM group, i.e. a spread of specific volatile index values, and furthermore, this spread increases with decrease in rank. In other words, a spread in chemical rank exists in each ASTM group and at the present time these chemical differences are not recognized by the classification. Therefore, it is suggested that the specific volatile index value of a coal precede the group name in its designation; for example, a 95 subbituminous C coal. Coals could then be easily compared within the same group; for example, a 95 subbituminous C coal as opposed to a 125 subbituminous C coal. The qualifying specific volatile index value shows in a quantitative manner that there are chemical differences between the two coals even though they are at approximately the same physical state of development. Such differences could be of possible significance in the utilization of the coal and they would certainly be of interest to the investigator studying the behavior, origin, petrographic composition and chemical composition of a coal.

The reasons for the differences in chemical rank of the low rank coals are not completely understood, but it is thought that they are mainly due to petrographic variation and to the state of chemical maturity of the peat at the time of burial. Recent peat deposits can be found in many different stages of maturity resulting from variations in their geochemical and biochemical environments. Chemical differences developed in the bog and during the diagenetic stage are not readily erased by metamorphism, and might persist to a diminishing degree well into the bituminous coal range. The petrographic components are highly variable depending on the nature of the organic sediments and the variable manner in which the components are preferentially preserved. Another important fact regarding the different petrographic components is that they exhibit their greatest chemical differences at the low rank end of the coalification band.

One of the basic reasons for the reactivation of the committee was to try and attain a better understanding of the influence of petrography on coal classification. In order to obtain a better understanding, the classification must first be rendered more sensitive to petrographic variation. It is thought that by separating the physical and chemical aspects of classification, another variable would be more fully understood, and the influence of petrographic variation might be more readily recognized in chemical terms, thus making it possible to integrate the petrographic and chemical spheres.

SUMMARY

In addition to the proposals in the first two sections of this report, it is suggested that coals should be classified according to both physical and chemical rank, and that this could be accomplished by qualifying the ASTM group designation with the numerical "specific volatile index". A coal classified as 130 subbituminous B could be quantitatively compared to other coals of the same group, and in addition, a given coal could be compared to a large number of other coals by referring it to a diagram such as figure 2.

- - - - -

LEK/ph